

# ABUNDANCES IN J-TYPE CARBON STARS

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## I) Introduction

It has been found by Utsumi(1985a,b) that in J-type carbon stars of C4-5 and WZ Cas(C9,2J Li), abundances of s-process elements with respect to Fe are nearly normal, while in normal carbon stars of C5-8, heavy metals are overabundant by factors of 10-100, and rare-earth elements are overabundant by a factor of about 10.

In the MK system, most J-type stars are classified as C4-5,4-5 stars which show very strong C<sub>2</sub> and CN bands. Yamashita(1972,1975) classified many C7-9 stars most of which are CS or SC stars. His classification of C7-9J stars is mainly based on C<sup>12</sup>C<sup>13</sup>(0,1)band at 6168 Å, C<sup>13</sup>N(4,0)band at 6260 Å, and LiI 6708 Å line. In most of C7-9 stars, lines of s-process elements are greatly enhanced. It is a question if in all J-type stars abundances of s-process elements are nearly normal or not.

## II) Observation

We tested the classification of J-type stars using the spectra obtained at the Okayama Astrophysical Observatory, in the region between 4400 Å and 6800 Å with a dispersion of about 13.5 Å/mm. Table 1 shows the stars studied together with the spectral type by the Harvard system and by Yamashita, and the C<sup>13</sup> index by Yamashita.

From the spectra between 6100 Å and 6300 Å, it is found that in all C7-9 stars it appears as if C<sup>13</sup> features are very strong with low dispersions, because C<sub>2</sub> and CN bands are weak, and strong low-excitation atomic lines coincide in chance with C<sup>13</sup> features. Table 2 shows the strong atomic lines which coincide in chance with these molecular bands. It is better to use C<sub>2</sub>(1,0)bands to find J-type stars.

Table 1

Star	Spectral Type	C <sup>13</sup>	Star	Spectral Type	C <sup>13</sup>
HD 16115	R3; C2,3J	4	R CMi	C7,1(J)e	4
HD 19557	R5; C4,5J	5	FU Mon	C8,0(J)	4
UV Cam	R8; C4,5J	4			
HD 52432	R5; C4,5J	5	WZ Cas	N1p; C9,2J Li	4
HD 79319	R4; C4,4J	4	WX Cyg	N3e; C9,2J Li	5
HD 168227	R5; C4,5J	5			
			U Hya	N2; C6,3	3+
Y CVn	N3; C5,5J	5	RR Her	K5ep; C8,2e	3+
RY Dra	N4; C4,5J	5	RS Cyg	N0pe; C8,2e	4
			U Cyg	Np; C8,2e	4

Table 2

Wavelength	Molecular Band	Wavelength	Atomic Line
6102 A	$C_{12}^{13}C_{13}^{13}(1,3)$	6102.72 A	CaI 3
6122	$C_{12}^{12}C_{12}^{12}(1,3)$	6122.22	CaI 3
6168	$C_{12}^{13}C_{13}^{13}(0,2)$	6170.34	VI 20
		6162.18	CaI 3
6191	$C_{12}^{12}C_{12}^{12}(0,2)$	6191.73	YI 3
6206	$C_{12}^{13}N(4,0)R_1$	-----	-----
6260	$C_{13}^{13}N(4,0)R_1$	6258.96	ScI 3
		6258.62	VI 19
		6261.23	VI 20

Among C7-9 stars studied, only WZ Cas certainly, and WX Cyg probably belong to J-type stars. Both stars belong to I1 stars which show unusually strong LiI 6708 A line. The other C7-9 stars in which lines of s-process elements are greatly enhanced are found not to belong to J-type stars. Hot J-type star HD 16115 is found to be certainly classified as a J-type star. It has been found that in HD 16115 abundances of s-process elements with respect to Fe are nearly normal.

### III) J-type stars in the Local Group galaxies

Richer et. al.(1979,1981,1983) made photometry and spectroscopy of many carbon stars in the Large Magellanic Cloud and other Local Group galaxies. They constructed the (I, R-I) color-magnitude diagram for these carbon stars. They also took spectra of these carbon stars, and classified them on the C-classification system as defined by Yamashita. They found two kinds of J-type stars, one is of high-luminosity stars with weak CN bands, and the other is of low-luminosity stars with strong CN bands.

We believe that luminous  $C^{13}$ -rich stars in the Local Group galaxies are not J-type but C7-9 stars including GS and SC stars, and "true" J-type stars are low-luminosity stars with very strong  $C^{13}$  bands, and I1 stars like WZ Cas.

It may be said that in all J-type stars abundances of s-process elements with respect to Fe are nearly normal.

### References

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